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HARDINESS AND YIELD OF WINTER-WHEAT VARIETIES

By KARL S. QUISENBERRY, *Associate Agronomist,* and J. ALLEN CLARK, *Senior Agronomist, Office of Cereal Crops and Diseases, Bureau of Plant Industry*

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IMPORTANCE OF HARDINESS IN WINTER WHEATS

Winterkilling causes a serious annual loss to the winter-wheat crop of the United States. Low temperature is the principal cause of winterkilling, although drought, soil blowing, heaving, and smothering are often contributing factors. During the 28-year period from 1901 to 1928 an average of nearly 11 per cent of the total winter-wheat acreage of the United States was abandoned annually, largely because of winterkilling. The average percentage of abandonment has been increasing slightly in recent years. From 1901 to 1907 the average abandonment was 8.7 per cent; from 1908 to 1914, 9 per cent; from 1915 to 1921, 10.5 per cent; and from 1922 to 1928 it was 14.2 per cent.

With a few exceptions winter wheat is more productive than spring wheat in all parts of the United States where it survives the winter. The longer period of growth, and the earlier maturity of winter wheat, which often enables it to evade injury from rust and drought, probably are the principal factors in causing the higher yields of winter wheat in comparison with spring wheat. The growing of winter wheat also permits a better distribution of labor than if spring grains only are grown.

In recent years the winter-wheat area has been expanding northward, which may be one reason for the increase in the percentage of abandonment. The reduction of losses due to winterkilling where winter wheats are now grown and the northward extension of the winter-wheat area would result in more economical and profitable production.

Winter injury may be reduced by the use of hardy varieties and by cultural practices, such as sowing in grain stubble or cornstalks,

the preparation of a firm seed bed by the use of a duck-foot fallow, sowing with furrow drills at proper rates and dates, and mulching the wheat with straw. The first method, involving the use of hardy varieties, is discussed in this circular.

The testing of many varieties and strains of wheat in northern sections where winterkilling frequently occurs has resulted in the discovery of several varieties possessing considerable hardiness. In order to determine more accurately the comparative hardiness of these, together with the hardiness of new hybrid productions, a uniform set of varieties has been sown at a number of experiment stations each year since the fall of 1919. The results of the first six years' experiments have been published previously.[1] This circular gives additional detailed data for the 4-year period 1926 to 1929 and a summary for the 10-year period.

Yields have been obtained on the surviving material at some of the cooperating stations since 1926. These yields are presented, with an account of the origin and value of the more important varieties.

PREVIOUS WORK

That wheat varieties differ in winter hardiness is common knowledge, and farm experience already has eliminated tender varieties from the Northern States. Differences in the hardiness of wheat varieties have been reported by many investigators in the United States and Europe. The breeding of hardy winter-wheat varieties has been given particular attention in Russia and Sweden. Only relatively hardy varieties of winter wheat can be grown in most parts of Russia. Attempts have been made to obtain varieties having greater hardiness by selecting surviving plants under extreme winterkilling conditions and by hybridizing wheat and rye. Observations in Sweden have shown that some varieties suffer little injury, whereas others are completely winterkilled. In that country hybrid selections with a higher survival than parent varieties have been isolated, showing that increased hardiness can be obtained by breeding. The hardiest varieties grown in Sweden, however, are less hardy than the hard red winter wheats grown in the United States and Russia. In the United States, the hardy varieties now grown either were introduced from Russia or are selections or hybrids from the introduced varieties. The origin of these varieties is discussed in a later part of this circular.

A fairly complete literature review of earlier work on winter hardiness was given in the first report of results from the uniform-hardiness nurseries.[2] In that report it also was shown that the varieties tested differ greatly in their ability to survive the winter. Minhardi, Buffum No. 17, and Odessa were the most hardy, while Turkey, Kanred, and Kharkof were less hardy.

The next step in the program was to combine, through breeding, the quality and yielding ability of hard wheats such as Kanred, Turkey, and Kharkof with the hardiness of the commercially less desirable Minhardi, Buffum No. 17, and Odessa. Reports on such

[1] CLARK, J. A., MARTIN, J. H., and PARKER, J. H. COMPARATIVE HARDINESS OF WINTER-WHEAT VARIETIES. U. S. Dept. Agr. Circ. 378, 20 p., illus. 1926.

[2] See footnote 1.

breeding investigations have been made by Martin [3] and Quisenberry and Clark.[4] Some promising hybrid selections have been developed from these experiments. Many of the experiment stations in the north-central United States and in Canada also have developed additional promising hybrid selections. The most outstanding new strains from any of these sources are included in the uniform winter-hardiness nurseries as they are available.

Attempts have been made to develop laboratory tests to measure cold resistance. Newton [5] found that certain chemical and physical properties of the plant gave a measure of cold resistance. Martin [6] applied these tests to hybrid material and concluded they were no better than careful field trials in obtaining data on segregation for cold resistance. Martin also conducted laboratory freezing tests to determine relative cold resistance. From these experiments he concluded that artificial freezing offered the best laboratory method for determining cold resistance. Hill and Salmon [7] conducted extensive freezing tests, using standard varieties. They were able to obtain fairly close correlation between laboratory and field results. Working with an F_3 generation of a winter-by-spring cross Quisenberry [8] obtained the important correlation of $+0.713 \pm 0.031$ between cold resistance as expressed by laboratory freezing tests and hardiness under field conditions.

In all the laboratory work conducted, the problem of getting the plant material properly hardened off has been one of the greatest importance. While laboratory tests may aid in the rapid elimination of tender hybrid material, the final measure of the most hardy segregates must be made by continued trials over a wide area in the field. Because of the need for field-hardiness data, this circular, covering 10 years' work, still must be considered as a continuing-progress report.

SCOPE OF INVESTIGATIONS

The experiments here reported were conducted at 30 experiment stations during one or more of the 10 years from 1920 to 1929. Results represent a total of 215 station years. As the detailed data for the 6-year period 1920 to 1925 have been presented by Clark, Martin, and Parker,[9] only summary figures for these years are given here. Not all the varieties were grown at all stations during all seasons. Beginning with the fall of 1925 the nursery was limited to 30 varieties each year. Uniform quantities of seed of each variety were prepared and sent to the various stations for sowing. Each variety was sown in triplicated rod rows. So far as possible the seed from all varieties was grown at the Kansas Agricultural Experiment Station, Manhattan, Kans., during the year in which

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[3] MARTIN, J. H. COMPARATIVE STUDIES OF WINTER HARDINESS IN WHEAT. Jour. Agr. Research 35: 493–535, illus. 1927.

[4] QUISENBERRY, K. S., and CLARK, J. A. BREEDING HARD RED WINTER WHEATS FOR WINTER HARDINESS AND HIGH YIELD. U. S. Dept. Agr. Tech. Bul. 136, 28 p. 1929.

[5] NEWTON, R. THE NATURE AND PRACTICAL MEASUREMENT OF FROST RESISTANCE IN WINTER WHEAT. Alberta Univ., Col. Agr. Research Bul. 1, 53 p., illus. 1924.

[6] See footnote 3.

[7] HILL, D. D., and SALMON, S. C. THE RESISTANCE OF CERTAIN VARIETIES OF WINTER WHEAT TO ARTIFICIALLY PRODUCED LOW TEMPERATURES. Jour. Agr. Research 35: 933–937. 1927.

[8] QUISENBERRY, K. S. INHERITANCE OF WINTER HARDINESS, GROWTH HABIT, AND STEM-RUST REACTION IN CROSSES BETWEEN MINHARDI WINTER AND H–44 SPRING WHEAT. U. S. Dept. Agr. Tech. Bul. 218. [In press.]

[9] See footnote 1.

it was sown. If there was not sufficient seed of any variety, seed from other sources, usually from North Platte, Nebr., and Moccasin, Mont., was added to that grown at Manhattan. Most of the new varieties when added to the experiment were grown from seed from stations other than Manhattan.

The wheat was sown and the survival data were taken by the cooperators at their respective stations.[10] The location of the uniform nurseries, the number of years the nursery was grown at each experiment station, and the names of the cooperators who obtained the data are shown in Table 1.

TABLE 1.—*Locations of stations, number of years that the uniform winter-hardiness nursery was grown at each station, and the cooperators who obtained the data reported in this circular*

Station	Number of years grown	Cooperator
United States:		
Manhattan, Kans.	10	John H. Parker.
Hays, Kans.	10	A. F. Swanson.
Akron, Colo.	5	F. A. Coffman.
Colby, Kans.	7	B. F. Barnes, E. H. Coles.
Ames, Iowa	9	L. C. Burnett.
Lincoln, Nebr.	9	T. A. Kiesselbach.
North Platte, Nebr.	6	G. F. Sprague.
Cheyenne, Wyo.	10	A. L. Nelson.
Brookings, S. Dak.	10	Matthew Fowlds, K. H. Klages.
Highmore, S. Dak.	1	E. S. McFadden.
Redfield, S. Dak.	5	Samuel Garver, E. S. McFadden.
Ashland, Wis.	10	E. J. Delwiche.
St. Paul, Minn.	9	H. K. Hayes, O. S. Aamodt.
Fargo, N. Dak.	10	L. R. Waldron.
Mandan, N. Dak.	10	E. R. Ausemus.
Dickinson, N. Dak.	10	R. W. Smith.
Bozeman, Mont.	9	I. J. Jensen, LeRoy Powers.
Moccasin, Mont.	10	R. W. May, B. B. Bayles.
Havre, Mont.	5	M. A. Bell.
Pullman, Wash.	5	E. F. Gaines.
Ithaca, N. Y.	9	H. H. Love.
Canada:		
Ste. Anne de Bellevue, Quebec	5	R. Summerby.
Ottawa, Ontario	5	L. H. Newman, A. G. O. Whiteside.
Morden, Manitoba	2	W. J. Breakey.
Indian Head, Saskatchewan	4	J. G. Davidson, G. B. Matthews.
Swift Current, Saskatchewan	2	H. J. Kemp.
Saskatoon, Saskatchewan	10	Manley Champlin, J. B. Harrington.
Lethbridge, Alberta	5	W. D. Hay.
Claresholm, Alberta	4	Wilfred Robinson.
Edmonton, Alberta	9	J. M. Manson, O. S. Aamodt.

An outline map of portions of the United States and Canada, showing the location of the experiment stations where hardiness nurseries were grown, is given in Figure 1.

The survival percentages were determined either by an estimation of the stands of plants in fall and spring or by actual counts of

[10] At Manhattan and Hays, Kans., Akron, Colo., North Platte, Nebr., Ames, Iowa, St. Paul, Minn., Highmore, S. Dak., Mandan and Dickinson, N. Dak., Moccasin, Mont., and Ithaca, N. Y., the experiments with wheat were in cooperation with the Office of Cereal Crops and Diseases during all the years in which the winter-hardiness nurseries were grown at these stations. At Cheyenne, Wyo., and Brookings and Redfield, S. Dak., the experiments with cereals were cooperative during part of the period of these tests. At Bozeman, Mont., and Pullman, Wash., some cereal experiments, but not the winter-hardiness nurseries, have been cooperative. The data from these stations and from Colby, Kans., Lincoln, Nebr., Ashland, Wis., Fargo, N. Dak., Havre, Mont., and the stations in Canada—Ste. Anne de Bellevue (Macdonald College), Quebec; Ottawa, Ontario; Morden, Manitoba; Indian Head, Swift Current, and Saskatoon, Saskatchewan; Lethbridge, Claresholm, and Edmonton, Alberta—were furnished by the courtesy of the stations and the cooperators whose names are listed in Table 1. The assistance of those who supplied the data from each of the 30 stations is gratefully acknowledged.

plants in all or portions of a row. The survivals reported are nearly all averages of the three rows of each variety. The data on survival are presented in Tables 2 to 6, inclusive.

Yield data have been obtained at some stations on surviving rows since 1926. Since the strains in the nurseries were grown in single rod rows replicated three times, the yields obtained were subject to considerable error because competition was not eliminated. In all cases, however, the varieties were arranged according to hardiness so that, in general, strains of more or less equal hardiness were grown together. The data on yield are presented in Tables 8 to 12, inclusive.

RESULTS ON WINTER HARDINESS

The survival percentages for each variety at each station and the averages for each variety each year are shown in Tables 2 to 5, inclusive. The results are summarized in Table 6. At some stations there was complete killing of all varieties. At other stations all

FIGURE 1.—Outline map of northern United States and southern Canada, showing the location of experiment stations at which uniform winter-hardiness nurseries were grown

varieties showed complete survival. At still other stations either survival or killing was nearly complete. At the remaining stations, where partial killing of nearly all varieties occurred, the most useful and significant data on hardiness were obtained. The differences in average survival, determined by including data from all stations, are rather slight, because of the results from stations where killing was either extremely heavy or extremely light.

Two sets of averages are given for each year, one for all stations and the other for certain stations from which the more significant data were obtained. In the latter averages the data were excluded from those stations where no killing occurred, where all varieties were completely killed, and also from Ithaca, N. Y., and Pullman, Wash., where the effects and probably the causes of killing differed from those at the other stations, as indicated by the survival of certain varieties. At Ithaca and Pullman the winters are relatively mild compared with those at the other stations, and the survival percentages recorded appear to be measures of adaptation and vigor rather than of resistance to cold.

Probable errors or other statistical constants for the average survival percentages during individual seasons or all seasons are not given, since ordinary statistical methods are not applicable to the data obtained. The writers believe, however, that there is no question of the significance of the differences in hardiness of such varieties as Minhardi, Minturki, Odessa, and Buffum No. 17, which are more hardy than the standard Kharkof, or of the lower degree of cold resistance of such varieties as Blackhull and Nebraska No. 28. It is doubtful whether the determination of probable errors would make it possible to draw trustworthy conclusions as to the significance of minor differences, such as those between different strains of Kharkof or between Kanred and the strains of Turkey other than C. I.[11] No. 6152.

RESULTS IN 1926

Winter-hardiness nurseries were sown in the fall of 1925 at 26 stations in the United States and Canada. The survival data are shown in Table 2. Differential killing occurred at all stations except Manhattan, Hays, and Colby, Kans., Lincoln, Nebr., Havre, Mont., and Ottawa, Ontario. At Mandan, N. Dak., killing was nearly complete, and at Fargo, N. Dak., killing was very heavy. Averaging the results from the stations where partial killing occurred it is found that Turkey × Minessa (C. I. No. 8028), Minhardi, Kanred × Buffum No. 17 (C. I. No. 8030), and Buffum No. 17 had the highest average survivals. Several additional hybrid strains which were included for the first time had very good survivals. Harvest Queen and Fulcaster, two varieties of soft wheat known to be rather tender, were included for comparison. These varieties, together with Blackhull, were lowest in average survival. Kanred had an average survival slightly lower than the Kharkof check.

RESULTS IN 1927

In the fall of 1926 winter-hardiness nurseries were sown at 26 stations. The data in Table 3 show that no killing occurred at Manhattan or Hays, Kans., or at Lincoln, Nebr. Very heavy killing occurred at Mandan and Dickinson, N. Dak., some of the less hardy varieties being completely killed at these stations. At Redfield, S. Dak., and Fargo, N. Dak., killing also was heavy, especially in the nonhardy varieties. Buffum No. 17, Minhardi, and Turkey × Minessa (C. I. No. 8028) had the highest average survivals at the stations where partial killing occurred. As in 1926, several of the hybrid strains had very high survivals. Fulcaster, Harvest Queen, and Blackhull were low in average survival.

RESULTS IN 1928

The winter-hardiness nursery was sown at 28 stations in the fall of 1927. No killing occurred at Pullman, Wash., and killing was complete at Fargo and Mandan, N. Dak., and Swift Current and Saskatoon, Saskatchewan, Canada. (Table 4.) At several other stations, especially Brookings and Redfield, S. Dak., Moccasin, Mont.,

[11] C. I. denotes accession number of the Office of Cereal Crops and Diseases.

and Indian Head, Saskatchewan, killing was very heavy. In general, there was good differentiation between the hardy and nonhardy varieties, although inconsistencies were present. At St. Paul, Minn., probably the sharpest differentiation occurred, since only the more hardy varieties, especially those adapted to the local conditions, survived. The nursery at Manhattan, Kans., was space planted in order to increase the chances of obtaining differential killing. The results obtained seemed to justify the procedure at this station, and the results are averaged with those from other stations. Buffum No. 17, Minhardi × Minturki (C. I. No. 8215), Turkey × Minhardi, and Kanred × Buffum No. 17 had the highest average survivals at the 20 stations where partial killing occurred. As in the previous years, several of the new hybrid strains had very good survivals. Fulcaster, Regal, Blackhull, and Superhard were the least hardy. In general, winterkilling was severe and the average survivals were somewhat lower than in the two previous years.

Superhard, which is a selection from Blackhull, proved to have no more hardiness than its parent. Oro, a smut-resistant selection from Turkey, proved to be equal in hardiness to the Kharkof check.

RESULTS IN 1929

In the fall of 1928 the number of nurseries sown was reduced to 24. Nurseries were discontinued at Pullman, Wash., Ithaca, N. Y., Ste. Anne de Bellevue, Quebec, and Ottawa, Ontario, because killing effects at these stations differed from those at other stations. No killing occurred during the winter at Hays, Kans., or at Lincoln, Nebr., while at Moccasin, Mont., survival was nearly complete. (Table 5.) Killing was complete at Mandan, N. Dak., and very heavy at Fargo, N. Dak., Havre, Mont., and Indian Head, Saskatchewan. The nursery at Manhattan, Kans., was space planted as in the previous year, and differential survival occurred there. Buffum No. 17, Minard × Minhardi, Minhardi, and Turkey × Minhardi (C. I. No. 8217) had the highest average survivals at the 21 stations where partial killing occurred. Fulcaster was continued as the tender check, Harvest Queen having been dropped. One new variety, Early Blackhull, had an average survival slightly lower than that of Fulcaster. While Early Blackhull has earliness, it is very tender, apparently being less hardy than either Blackhull or Superhard. Kawvale, a soft to semihard red winter wheat produced at the Kansas station, proved to be considerably more hardy than Fulcaster, but less hardy than the Kharkof check. Oro was again about equal to Kharkof in hardiness.

TABLE 2.—*Average survival in the spring of 1926 of 30 varieties of winter wheat grown in triplicated rod rows to determine winter hardiness at 26 experiment stations in the northern United States and in Canada during the winter of 1925–26*

[T=trace. Data from Manhattan, Hays, and Colby, Kans., Lincoln, Nebr., Havre, Mont., and Ottawa, Ontario, where survival of all varieties was complete, are omitted from the table]

Class and variety	C. I. No.	State No.	Survival (per cent) at—																				Average for—	
			Ames, Iowa	North Platte, Nebr.	Cheyenne, Wyo.	Ashland, Wis.	St. Paul, Minn.	Brookings, S. Dak.	Redfield, S. Dak.	Fargo, N. Dak.	Mandan, N. Dak.	Dickinson, N. Dak.	Bozeman, Mont.	Moccasin, Mont.	Pullman, Wash.	Ithaca, N. Y.	Ste. Anne de Bellevue, Quebec	Indian Head, Saskatchewan	Saskatoon, Saskatchewan	Lethbridge, Alberta	Claresholm, Alberta	Edmonton, Alberta	26 stations[1]	18 stations[2]
Hard red winter:																								
Kharkof	1442		93	95	100	65	19	38	75	0	0	7	90	86	74	25	8	28	52	98	85	82	66.2	56.7
Montana No. 36	5549	Mont. 36	95	95	100	56	19	42	75	0	0	2	93	86	77	17	6	40	56	99	98	82	66.8	58.0
Karmont	6700		96	93	88	54	22	42	78	0	T	8	91	81	66	22	10	33	57	100	67	85	65.1	55.8
Turkey (selection)	6152	Minn. 1488	97	93	100	75	67	38	60	4	0	4	94	94	71	18	62	58	63	100	72	83	71.3	64.7
Nebraska No. 60	6250	Nebr. 60	93	93	100	60	28	30	42	1	0	40	96	78	74	19	51	56	56	100	65	85	68.0	59.7
Beloglina	1543		93	94	100	80	60	43	77	1	0	9	93	93	65	17	54	42	72	99	70	88	71.2	64.9
Do	1667		95	92	100	73	58	42	81	0	0	32	91	90	70	24	25	35	73	99	77	88	71.0	63.9
Blackhull	6251		95	77	80	71	8	6	26	0	0	3	92	76	68	20	1	5	7	99	75	87	57.5	44.9
Newturk	6935		93	88	100	76	60	33	68	0	0	16	90	85	78	24	17	36	51	97	68	88	68.0	59.2
Iobred	6934	Iowa 1949	97	90	100	61	47	30	46	T	0	2	90	89	62	19	29	35	43	99	80	87	65.6	56.9
Ashkof	6680	Wis. 11. 825	97	95	100	90	57	33	71	0	0	4	93	97	68	14	36	47	46	97	78	85	69.5	62.6
Kharkof (selection)	6938	M. C. 2212	95	93	100	84	50	37	69	4	0	7	94	94	64	14	76	69	79	99	88	92	73.4	68.3
Minard	6690	Minn. 2199	96	95	100	76	60	33	66	2	T	4	98	96	69	9	68	59	65	98	63	90	71.0	64.9
Padui	6153	Minn. 1491	95	93	100	90	63	22	47	4	T	5	97	98	81	7	64	68	60	97	77	90	71.5	65.0
Minturki	6155	Minn. 1507	97	93	100	90	80	23	49	5	T	12	99	92	72	5	59	70	76	98	57	90	71.8	66.1
Tenmarq	6936	Kans. 439	96	81	97	67	2	10	32	0	T	6	91	75	72	8	17	5	20	98	58	87	58.5	46.8
Kanmarq	6937	Kans. 440	95	81	83	64	3	13	19	0	T	10	90	72	70	11	15	10	25	98	78	88	58.7	46.9
P-1068 × Preston	8027	Kans. 446	98	83	90	65	17	11	49	0	0	10	92	76	77	5	13	9	36	98	77	88	61.3	50.7
Kanred	5146	Kans. 2401	94	88	100	79	23	13	43	0	0	16	90	72	84	7	17	18	41	98	58	93	62.8	52.4
Turkey × Minessa	8028		93	93	93	64	88	40	48	18	2	50	97	100	87	9	73	75	66	99	72	98	75.6	70.5
Kanred × Buffum No. 17	8030		87	91	93	64	73	47	77	6	2	79	95	99	87	18	75	69	59	96	58	98	75.9	70.4
Kanred × Minhardi	8031		89	95	100	63	80	48	81	10	T	39	93	100	73	6	73	54	68	99	48	97	73.7	68.7
Kanred × Minturki	8032		89	91	80	70	37	22	48	1	1	26	92	91	95	11	30	27	34	99	58	95	65.3	55.1
Minturki × Beloglina-Buffum	8033		90	93	93	68	83	43	78	7	T	21	93	92	86	8	82	72	65	99	47	95	73.7	67.8
Minhardi × Minturki	8034		95	96	100	70	82	42	66	3	T	20	96	98	82	6	83	62	64	99	43	97	73.2	67.6

Soft red winter:																							
Buffum No. 17	3330		92	94	100	48	90	50	74	3	T	2	95	94	70	3	92	84	76	100	70	90	74.1	69.7
Minhardi	5149	Minn. 1505	93	95	93	60	93	45	81	8	0	14	93	97	73	4	91	70	71	97	73	93	74.8	70.4
Odessa	6151	Minn. 1471	93	95	80	57	75	37	80	1	T	3	91	90	58	2	92	69	62	99	72	95	71.2	66.2
Harvest Queen	6199	Kans. 19	92	90	60	57	9	12	54	0	T	4	88	82	81	2	5	6	17	99	92	67	58.3	46.3
Fulcaster	6471	Kans. 317	92	83	77	35	2	10	17	0	0	3	91	53	(3)	5	T	4	4	98	65	48	[4] 51.5	37.9

[1] Includes Manhattan, Hays, and Colby, Kans.; Lincoln, Nebr.; Havre, Mont.; and Ottawa, Ontario, where no killing occurred.
[2] Excludes Pullman, Wash., and Ithaca, N. Y., where killing effects differed from those at other stations.
[3] Not sown.
[4] Average of 25 stations.

TABLE 3.—*Average survival in the spring of 1927 of 30 varieties or strains of winter wheat grown in triplicated rod rows to determine winter hardiness at 26 experiment stations in the northern United States and in Canada during the winter of 1926–27*

[T=trace. Data from Manhattan and Hays, Kans., and Lincoln, Nebr., where survival of all varieties was complete, are omitted from the table]

Class and variety	C. I. No.	State No.	Survival (per cent) at—																								Average for—	
			Colby, Kans.	Ames, Iowa	North Platte, Nebr.	Cheyenne, Wyo.	Ashland, Wis.	St. Paul, Minn.	Brookings, S. Dak.	Redfield, S. Dak.	Fargo, N. Dak.	Mandan, N. Dak.	Dickinson, N. Dak.	Bozeman, Mont.	Moccasin, Mont.	Havre, Mont.	Pullman, Wash.	Ithaca, N. Y.	Ste. Anne de Bellevue, Quebec	Ottawa, Ontario	Indian Head, Saskatchewan	Saskatoon, Saskatchewan	Lethbridge, Alberta	Claresholm, Alberta	Edmonton, Alberta	26 stations [1]	19 stations [2]
Hard red winter:																												
Kharkof	1442		85	91	93	50	31	96	72	T	0	T	T	83	97	94	100	88	88	98	83	68	9	70	33	66.5	55.5
Montana No. 36	5549	Mont. 36	82	93	100	50	27	92	72	0	0	1	T	93	98	97	100	86	86	100	94	68	9	96	48	68.9	58.9
Karmont	6700		90	97	100	50	41	95	72	2	0	T	T	93	98	99	100	86	85	100	88	68	9	88	50	69.7	60.0
Turkey (selection)	6152	Minn. 1488	66	96	100	53	65	100	72	2	10	1	1	95	100	98	100	87	88	100	86	80	16	94	52	71.6	62.5
Nebraska No. 60	6250	Nebr. 60	81	93	98	60	51	100	72	3	2	2	1	93	96	98	100	81	82	100	89	77	13	89	52	70.5	61.6
Beloglina	1543		65	94	100	60	48	100	83	7	T	3	2	93	100	99	98	84	86	99	91	82	27	91	52	71.7	63.0
Do	1667		69	95	98	60	43	97	85	5	0	4	2	82	98	99	97	88	89	96	90	77	26	91	55	71.0	61.9
Blackhull	6251		65	91	63	13	40	57	37	1	0	T	T	95	35	79	100	88	86	98	79	52	4	38	43	56.3	41.7
Kanred	5146	Kans. 2401	88	93	93	58	55	97	58	2	0	1	T	88	94	94	97	80	82	96	81	78	16	76	35	67.8	58.3
Tenmarq	6936	Kans. 439	53	92	85	62	42	79	37	1	0	T	T	92	55	94	100	84	84	94	71	65	4	53	50	61.4	49.2
Newturk	6935		75	95	97	62	75	72	63	1	3	1	1	88	87	99	98	83	74	96	87	68	6	63	42	66.8	57.1
Iobred	6934	Iowa 1949	62	96	97	47	77	86	62	T	2	0	1	93	97	99	98	82	79	96	80	62	7	79	42	67.1	57.3
Ashkof	6680	Wis. 11.825	70	96	78	47	81	97	67	T	2	T	T	92	100	100	98	84	75	99	88	78	11	88	47	69.2	60.1
Kharkof (selection)	6938	M. C. 2212	46	85	87	50	52	98	83	8	12	2	4	83	99	100	67	74	60	96	87	70	23	88	58	66.6	59.7
Minard	6690	Minn. 2199	50	95	92	58	79	98	85	8	21	T	1	92	100	99	98	82	85	99	88	87	17	96	48	72.2	63.9
Padui	6153	Minn. 1491	77	93	95	62	84	100	81	7	27	T	2	88	100	100	97	74	80	97	90	80	11	84	70	73.0	65.8
Minturki	6155	Minn. 1507	61	97	97	58	50	100	92	15	32	1	3	90	100	100	95	78	81	99	87	87	15	87	57	72.4	64.7
Turkey × Minessa	8028		59	94	97	60	63	100	93	9	12	2	3	85	100	100	95	76	76	99	86	77	22	89	88	72.5	65.2
Kanred × Buffum No. 17	8030		71	91	93	72	72	100	90	31	7	T	5	82	100	100	98	77	78	98	94	77	22	82	93	74.3	67.5
Kanred × Minhardi	8031		59	91	98	43	60	100	95	13	1	6	9	87	100	100	92	75	72	96	83	65	23	72	85	70.2	62.6
Minturki × Beloglina-Buffum	8033		70	97	95	53	77	100	93	48	2	5	6	98	100	100	100	76	74	97	89	77	20	72	92	74.7	68.1
Minhardi × Minturki	8034		78	94	88	40	63	100	95	7	0	3	3	98	100	99	97	77	76	94	96	80	11	76	93	71.8	64.4
Eureka × Minhardi	8036		66	94	97	38	68	100	95	15	0	5	5	95	100	100	100	73	70	99	91	78	18	84	88	72.3	65.1
Kanred × Minhardi	8040		71	96	97	27	69	100	95	13	1	9	4	93	100	100	93	74	71	99	91	80	23	82	77	71.7	64.6
Minhardi × Minturki	8047		70	92	83	32	82	100	93	8	1	3	2	93	100	100	100	80	76	100	97	82	20	79	93	72.5	64.7

Soft red winter:																										
Buffum No. 17	3330		72	97	93	38	63	100	91	25	50	3	6	95	100	100	97	75	80	97	87	90	31	89	95	75.9	69.7
Minhardi	5149	Minn. 1505	76	97	97	57	42	100	96	5	69	3	7	92	100	100	95	75	83	100	83	83	29	95	87	75.8	69.4
Odessa	6151	Minn. 1471	66	96	92	32	58	100	82	13	20	T	3	93	99	100	95	80	83	100	83	82	19	83	95	72.1	64.0
Harvest Queen	6199	Kans. 19	60	96	64	25	43	99	42	2	2	0	0	92	78	91	100	80	88	100	82	72	5	69	62	63.5	51.8
Fulcaster	6471	Kans. 317	42	90	62	28	40	64	20	0	0	0	0	93	40	77	100	79	82	95	85	48	0	42	58	55.6	41.5

[1] Includes Manhattan, and Hays, Kans., and Lincoln, Nebr., where no killing occurred.
[2] Excludes Pullman, Wash., Ithaca, N. Y., Ste. Anne de Bellevue, Quebec, and Ottawa, Ontario, where killing effects differed from those at other stations.

TABLE 4.—*Average survival in the spring of 1928 of 30 varieties or strains of winter wheat grown in triplicated rod rows to determine winter hardiness at 28 experiment stations in the northern United States and Canada during the winter of 1927–28*

[T=trace. Data from Pullman, Wash., where survival of all varieties was complete, and from Fargo and Mandan, N. Dak., Swift Current and Saskatoon, Saskatchewan, where killing was complete, are omitted from the table]

Class and variety	C. I. No.	State No.	Survival (per cent) at—																							Average for—	
			Manhattan, Kans.[1]	Hays, Kans.	Colby, Kans.	Ames, Iowa	Lincoln, Nebr.	North Platte, Nebr.	Cheyenne, Wyo.	Ashland, Wis.	St. Paul, Minn.	Brookings, S. Dak.	Redfield, S. Dak.	Dickinson, N. Dak.	Bozeman, Mont.	Moccasin, Mont.	Havre, Mont.	Ithaca, N. Y.	Ste. Anne de Bellevue, Quebec	Ottawa, Ontario	Morden, Manitoba	Indian Head, Saskatchewan	Lethbridge, Alberta	Claresholm, Alberta	Edmonton, Alberta	28 stations[2]	20 stations[3]
Hard red winter:																											
Kharkof	1442		88	99	3	48	76	57	85	11	0	0	T	30	100	1	91	39	27	31	5	0	8	53	100	37.6	42.8
Kharkof (selection)	6938	M. C. 2212	86	100	13	100	80	87	68	17	0	0	4	24	98	16	99	43	22	23	5	T	15	75	97	41.9	49.2
Montana No. 36	5549	Mont. 36	85	100	3	30	62	60	83	21	0	0	1	53	100	1	85	30	12	21	0	0	1	70	93	36.1	42.4
Karmont	6700		91	99	1	20	55	50	68	19	0	0	1	21	98	T	79	25	15	20	0	0	3	67	95	33.1	38.4
Newturk	6935		89	97	3	15	57	40	80	11	0	0	0	24	98	T	90	22	15	24	0	0	7	59	98	33.2	38.4
Regal	7364		81	99	0	1	61	25	70	4	0	0	0	11	100	0	33	32	32	30	0	0	1	27	93	28.6	30.3
Oro	8220		88	100	9	60	69	83	78	8	0	0	0	32	98	1	96	46	14	32	1	0	9	33	92	37.5	42.9
Beloglina	1543		89	100	11	77	76	90	82	26	0	0	0	43	97	1	99	39	12	26	2	0	43	95	97	43.0	51.4
Nebraska No. 60	6250	Nebr. 60	93	100	13	48	72	90	85	14	0	0	1	46	100	1	82	40	9	20	0	0	19	90	95	39.9	47.9
Kanred	5146	Kans. 2401	88	100	17	50	66	73	75	20	0	0	0	44	97	T	93	34	15	7	0	0	24	73	95	38.3	45.8
Blackhull	6251		68	100	4	5	74	30	53	3	0	0	0	7	97	T	23	27	4	9	0	0	0	38	68	25.4	28.5
Superhard	8054		80	98	3	0	74	13	73	1	0	0	0	21	100	0	35	26	10	10	0	0	0	38	77	27.1	30.7
Tenmarq	6936	Kans. 439	69	99	7	28	74	33	60	3	0	0	0	59	100	0	53	41	12	5	0	0	2	35	73	30.5	34.8
Iobred	6934	Iowa 1949	85	97	7	67	80	68	83	11	0	0	0	40	99	T	65	42	37	2	0	0	6	30	82	38.8	45.2
Turkey × Minessa	8028		93	74	18	100	86	100	93	27	2	T	7	43	100	25	98	47	35	4	9	13	78	99	98	48.2	58.2
Kanred × Buffum No. 17	8030		94	86	10	87	71	95	90	19	2	0	2	84	100	10	99	41	17	6	70	6	82	96	100	48.8	60.2
Kanred × Minhardi	8031		94	87	18	100	61	97	87	10	3	2	5	53	100	17	96	36	12	15	3	6	79	98	100	45.7	55.8
Minturki × Beloglina-Buffum	8033		90	81	15	85	67	82	92	21	4	T	6	54	95	6	100	33	1	5	75	9	75	100	98	46.2	57.8
Minhardi × Minturki	8034		94	90	20	100	57	88	80	20	2	0	2	45	99	7	99	43	17	8	2	2	53	96	100	43.7	52.8
Eureka × Minhardi	8036		91	87	15	85	67	100	80	34	28	T	7	39	98	29	98	33	23	4	0	5	82	98	100	46.5	57.2
Turkey (selection)	6152	Minn. 1488	92	85	18	84	59	77	70	25	18	0	2	37	100	6	75	42	40	8	2	1	67	96	98	42.9	50.6
Minturki	6155	Minn. 1507	94	93	23	90	79	90	85	33	18	0	2	76	97	8	95	43	30	2	75	1	22	98	97	48.3	58.8
Minard	6690	Minn. 2199	90	88	18	80	82	93	78	29	14	0	3	40	94	4	90	41	10	11	75	2	18	93	97	44.6	54.4
Minhardi × Minturki	8215	Minn. II–19–7	92	57	30	97	74	97	72	41	53	6	9	30	100	21	100	44	23	2	95	13	83	96	100	51.3	63.3
Turkey × Minhardi	8217	Minn. II–19–31	94	85	19	87	75	97	75	42	37	1	5	48	99	14	98	65	22	3	75	12	89	97	100	51.4	62.5

Soft red winter:																									
Minhardi	5149	Minn. 1505	94	74	21	90	82	97	80	47	22	4	11	47	97	29	78	45	14	4	14	14	93	95	100	48.3	59.5
Odessa	6151	Minn. 1471	91	96	13	55	80	57	82	40	7	0	6	26	100	8	99	59	17	10	18	4	80	99	100	44.5	53.1
Buffum No. 17	3330		95	83	30	94	72	100	78	38	7	1	6	69	100	21	100	34	9	15	93	14	91	98	100	51.7	64.5
Harvest Queen	6199	Kans. 19	67	99	4	15	67	53	63	37	0	0	1	34	99	T	71	41	20	24	1	0	7	25	100	33.1	37.2
Fulcaster	6471	Kans. 317	58	99	2	0	74	15	50	25	0	0	T	15	100	T	27	44	6	54	0	0	0	5	92	27.4	28.1

[1] Space planted.
[2] Including Pullman, Wash., where no killing occurred, and Fargo and Mandan, N. Dak., Swift Current and Sakatoon, Saskatchewan, Canada, where complete killing occurred.
[3] Excluding Ithaca, N. Y., Ste. Anne de Bellevue, Quebec, and Ottawa, Ontario, where killing effects differed from those at other stations.

TABLE 5.—*Average survival in spring of 1929 of 30 varieties or strains of winter wheat grown in triplicated rows to determine winter hardiness at 24 experiment stations in the northern United States and in Canada during the winter of 1928–29*

[T=trace. Data from Hays, Kans., and Lincoln, Nebr., where the survival of all varieties was complete, and from Mandan, N. Dak., where killing was complete, are omitted from the table]

Class and variety	C.I. No.	State No.	Survival (per cent) at—																			Average for—	
			Manhattan, Kans.[1]	Colby, Kans.	Ames, Iowa	North Platte, Nebr.	Cheyenne, Wyo.	Ashland, Wis.	St. Paul, Minn.	Brookings, S. Dak.	Redfield, S. Dak.	Fargo, N. Dak.	Dickinson, N. Dak.	Bozeman, Mont.	Moccasin, Mont.	Havre, Mont.	Morden, Manitoba	Indian Head, Saskatchewan	Swift Current, Saskatchewan	Saskatoon, Saskatchewan	Lethbridge, Alberta	Claresholm, Alberta	Edmonton, Alberta	24 stations[2]	21 stations
Hard red winter:																									
Kharkof	1442		74	82	83	98	75	99	82	97	27	0	29	93	100	3	68	1	26	7	100	68	1	58.9	57.8
Kharkof (selection)	6938	M. C. 2212	86	86	90	97	75	98	95	100	45	0	29	96	100	8	66	5	25	21	100	85	2	62.9	62.3
Montana No. 36	5549	Mont. 36	91	81	91	97	75	99	74	97	25	0	47	98	100	6	58	T	30	5	100	83	1	60.8	59.9
Karmont	6700		77	82	90	97	80	97	55	97	30	0	31	98	100	6	38	1	28	5	98	84	1	58.1	56.9
Newturk	6935		89	81	93	97	78	99	63	98	30	0	19	98	100	7	27	1	20	7	99	89	7	58.4	57.2
Oro	8220		88	80	94	95	82	97	83	98	29	0	18	98	100	4	18	1	18	7	99	92	5	58.6	57.4
Beloglina	1543		98	68	94	95	82	99	83	100	52	0	11	97	100	6	19	2	19	8	99	93	7	59.7	58.7
Nebraska No. 60	6250	Nebr. 60	94	71	99	95	78	97	61	98	50	0	19	96	100	4	21	1	24	5	99	95	12	59.1	58.0
Kanred	5146	Kans. 2401	92	80	95	95	88	98	86	100	43	0	20	98	100	9	39	1	26	7	97	88	12	61.4	60.7
Blackhull	6251		64	61	92	50	53	96	48	85	4	0	13	98	100	2	27	1	12	3	96	56	9	48.8	46.2
Superhard	8054		61	57	95	52	62	96	47	40	3	0	14	98	100	2	26	0	25	3	92	58	10	47.5	44.8
Early Blackhull	8856		78	50	95	40	73	97	55	20	1	0	21	97	100	1	27	0	3	2	94	55	7	46.5	43.6
Tenmarq	6936	Kans. 439	93	72	97	80	78	97	76	95	8	0	16	100	100	3	27	T	9	6	97	63	12	55.4	53.8
Kanred × Buffum No. 17	8030		91	84	90	98	85	94	100	100	75	5	21	87	100	10	32	7	22	30	100	84	20	64.0	63.6
Kanred × Minhardi	8031		68	76	85	97	75	96	97	96	65	1	30	95	100	2	31	7	10	37	100	83	25	61.5	60.8
Minturki × Beloglina-Buffum	8033		75	81	98	98	88	97	94	100	78	3	27	95	100	4	13	8	17	22	99	83	30	62.9	62.4
Minhardi × Minturki	8034		74	76	97	98	88	97	98	100	73	3	30	100	100	3	18	4	17	28	100	89	30	63.5	63.0
Eureka × Minhardi	8036		87	79	95	97	90	97	97	100	75	4	29	98	100	2	6	5	18	35	100	88	33	64.0	63.6
Kanred × Minhardi	8040		77	84	94	100	85	98	100	98	63	1	37	98	100	2	18	6	11	27	99	92	35	63.5	63.1
Turkey (selection)	6152	Minn. 1488	71	75	100	93	85	99	94	99	52	1	22	98	100	5	18	2	8	22	99	88	37	61.2	60.4
Minturki	6155	Minn. 1507	92	78	97	95	88	100	99	99	70	1	20	98	100	18	33	4	10	28	99	73	45	64.5	64.1
Minhardi × Minturki	8215	Minn. II–19–7	88	80	92	93	90	97	99	99	80	4	23	100	100	8	26	8	9	32	100	84	45	64.9	64.6
Turkey × Minhardi	8216	Minn. II–19–29	80	67	91	92	93	99	100	100	70	1	27	100	100	7	28	3	16	23	100	84	47	63.7	63.2
Do	8217	Minn. II–19–31	91	76	100	93	95	98	97	97	68	1	18	100	100	7	38	3	18	33	100	85	49	65.3	65.1
Minard×Minhardi	8218	Minn. II–20–20	98	75	92	95	93	99	99	99	68	2	20	100	100	9	38	5	23	37	100	85	50	66.1	66.0

Soft red winter:																									
Minhardi	5149	Minn. 1505	93	82	93	95	92	95	99	98	73	4	22	97	100	13	20	4	23	36	100	87	43	65.4	65.2
Odessa	6151	Minn. 1471	80	81	93	98	77	89	100	100	70	7	20	100	100	20	17	3	25	37	100	92	43	64.7	64.4
Buffum No. 17	3330		72	77	99	100	92	93	100	100	82	7	29	98	100	28	7	3	21	46	100	91	43	66.2	66.1
Kawvale	8180	Kans. 2593	88	67	100	90	82	98	95	87	12	T	9	95	98	2	5	T	18	8	99	50	27	55.4	53.8
Fulcaster	6471	Kans. 317	79	55	89	62	37	97	70	45	5	1	14	100	98	2	5	1	18	3	99	24	32	47.3	44.6

[1] Space planted.
[2] Includes Hays, Kans., and Lincoln, Nebr., where no killing occurred and Mandan, N. Dak., where killing was complete.

SUMMARY OF HARDINESS RESULTS

The annual and weighted average percentages of survival of each variety that has been included in the experiments for one or more which partial winterkilling occurred. In the case of the varieties was grown previous to 1926 the average survivals for each year are given. The percentages shown are the averages for the stations at which partial winterkilling occurred. In the case of the varieties that have been grown since the experiment was started the results included are for 150 station years. The survivals in percentage of Kharkof are presented in the last column of the table, and the varieties are arranged within their classes according to this percentage. A total of 42 varieties was tested during the 4-year period 1926 to 1929. There were 27 varieties that had an average survival higher than Kharkof, 24 being grown for a period of two years or more. Certain of the hybrid strains seem to be fully as hardy as Minhardi.

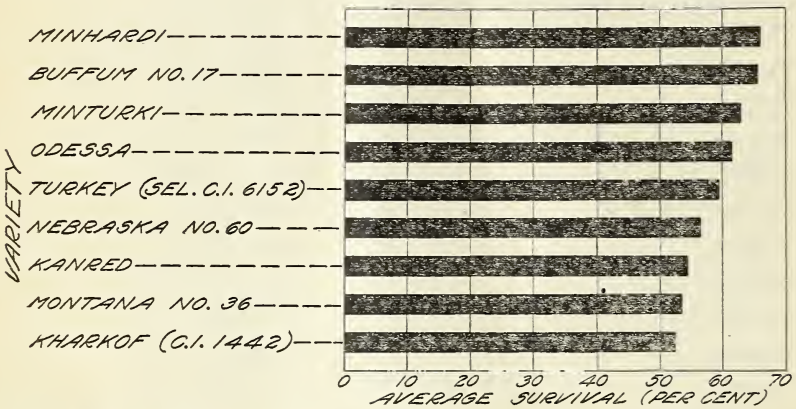

FIGURE 2.—Weighted-average survival of nine varieties of winter wheat grown in each of the 10 years from 1920 to 1929, inclusive, and for 150 station years when partial killing occurred

The varieties may be placed roughly in four winter-hardiness groups—very hardy, midhardy, slightly hardy, and tender. In the very hardy group are such varieties as Minhardi, Buffum No. 17, and several of the newer hybrid strains. In the midhardy group are Minturki, Odessa, Minard, Beloglina (C. I. 1543), and Turkey (C. I. 6152). The slightly hardy group includes Nebraska No. 60, Kanred, Kharkof, Karmont and Newturk, and varieties of similar hardiness. The tender group consists of such varieties as Tenmarq, Blackhull, Superhard, Harvest Queen, and Fulcaster. Such a grouping is of course arbitrary, since there are no sharp lines of demarcation between one group and another, the different varieties ranging in a rather complete series from tender to very hardy. It would seem, however, that these averages, based on a large number of observations, should at least indicate the more broadly different inherent degrees of cold resistance. The writers believe, therefore, that while the groupings are arbitrary, the differences between the groups are actual and inherent, the minor differences within the groups probably being largely due to environment.

ERRATUM

(Circular 141, U. S. Department of Agriculture)

The first two sentences under the heading "Summary of Hardiness Results," at the top of page 16, should read as follows:

"The annual and weighted average percentages of survival of each variety that has been included in the experiments for one or more years from 1926 to 1929 are shown in Table 6. Where the variety was grown previous to 1926, the average survivals for each year are given."

TABLE 6.—*Annual and average percentages of survival of 42 varieties of wheat grown during one or more of the years since 1925, and the complete record of these for the 10 years from 1920 to 1929, inclusive*

Class and variety	C. I. No.	Survival (per cent) in—										Average (weighted)	Kharkof same years	Number of station years	Percentage of Kharkof
		1920 (9 stations)	1921 (12 stations)	1922 (11 stations)	1923 (9 stations)	1924 (16 stations)	1925 (15 stations)	1926 (18 stations)	1927 (19 stations)	1928 (20 stations)	1929 (21 stations)				
Hard red winter:															
Turkey × Minessa	8028							70.5	69.2	58.2		65.8	51.4	57	128.0
Minhardi × Minturki	8215									63.3	64.6	64.0	50.5	41	126.7
Turkey × Minhardi	8217									62.5	65.1	63.8	50.5	41	126.3
Kanred × Buffum No. 17	8030							70.4	67.5	60.2	63.6	65.2	53.1	78	122.8
Minturki × Beloglina-Buffum	8033							67.8	68.1	57.8	62.4	63.9	53.1	78	120.3
Minturki	6155	31.1	84.2	60.9	53.8	67.4	64.3	66.1	64.7	58.8	64.1	62.9	52.8	150	119.1
Eureka × Minhardi	8036								65.1	57.2	63.6	61.9	52.1	60	118.8
Minard	6690					61.7	57.9	64.9	63.9	54.4		60.5	51.8	88	116.8
Minhardi × Minturki	8047								64.7			64.7	55.5	19	116.6
Kanred × Minhardi	8031							68.7	62.6	55.8	60.8	61.8	53.1	78	116.4
Minhardi × Minturki	8034							67.6	64.4	52.8	63.0	61.8	53.1	78	116.4
Padui	6153	30.0	81.8	57.2	50.2	66.2	64.1	65.0	65.8			62.1	53.6	109	115.9
Beloglina	1543						60.1	64.9	63.0	51.4	58.7	59.4	51.6	93	115.1
Kharkof (selection)	6938					61.4	64.0	68.3	59.7	49.2	62.3	60.5	52.9	109	114.4
Minard × Minhardi	8218										66.0	66.0	57.8	21	114.2
Turkey (selection)	6152	30.7	83.2	53.9	47.7	65.8	63.0	64.7	62.5	50.6	60.4	59.5	52.8	150	112.7
Kanred × Minhardi	8040								64.6		63.1	63.8	56.7	40	112.5
Ashkof	6680			50.2	50.7	65.3	56.3	62.6	60.1			58.7	52.9	88	111.0
Beloglina	1667	31.0	83.8	49.4	50.3	64.4	53.3	63.9	61.9			59.1	53.6	109	110.3
Turkey × Minhardi	8216										63.2	63.2	57.8	21	109.3
Nebraska No. 60	6250	26.8	80.8	51.5	45.2	63.1	60.5	59.7	61.6	47.5	58.0	56.8	52.8	150	107.6
Kanred	5146	29.8	78.3	48.4	49.8	62.8	48.1	52.4	58.3	45.8	60.7	54.4	52.8	150	103.0
Iobred	6934					59.2	48.6	56.9	57.3	45.2		53.3	51.8	88	102.9
Montana No. 36	5549	30.3	79.7	49.5	41.7	60.4	47.1	58.0	58.9	42.4	59.9	53.9	52.8	150	102.1
Kharkof	1442	29.8	77.3	50.2	44.3	60.6	43.7	56.7	55.5	42.8	57.8	52.8		150	100.0
Karmont	6700		77.8	48.3	42.4	61.0	46.1	55.8	60.0	38.4	56.9	54.1	54.2	141	99.8
Oro	8220									42.9	57.4	50.3	50.5	41	99.6
Newturk	6935					57.8	41.7	59.2	57.1	38.4	57.2	52.0	52.9	109	98.3
Kanred × Minturki	8032							55.1				55.1	56.7	18	97.2
Kanmarq	6937					54.9	45.0	46.9				48.9	54.0	49	90.6
P-1068 × Preston	8027						40.3	50.7				46.0	50.8	33	90.6
Tenmarq	6936					50.5	38.4	46.8	49.2	34.8	53.8	45.8	52.9	109	86.6
Regal	7364						42.9			30.3		35.7	43.2	35	82.6
Blackhull	6251		61.8	40.7	28.7	52.3	36.6	44.9	41.7	28.5	46.2	42.4	54.2	141	78.2
Early Blackhull	8856										43.6	43.6	57.8	21	75.4
Superhard	8054									30.7	44.8	37.9	50.5	41	75.0

10475—30—2

TABLE 6.—*Annual and average percentages of survival of 42 varieties of wheat grown during one or more of the years since 1925, and the complete record of these for the 10 years from 1920 to 1929, inclusive*—Continued

Class and variety	C. I. No.	Survival (per cent) in—												Number of station years	Percentage of Kharkof
		1920 (9 stations)	1921 (12 stations)	1922 (11 stations)	1923 (9 stations)	1924 (16 stations)	1925 (15 stations)	1926 (18 stations)	1927 (19 stations)	1928 (20 stations)	1929 (21 stations)	Average (weighted)	Kharkof same years		
Soft red winter:															
Minhardi	5149	37.4	84.3	67.4	55.6	70.0	69.7	70.4	69.4	59.5	65.2	66.0	52.8	150	125.0
Buffum No. 17	3330	33.2	83.5	57.5	57.2	67.5	72.5	69.7	69.7	64.5	66.1	65.8	52.8	150	124.6
Odessa	6151	32.4	80.8	55.6	49.3	70.9	66.7	66.2	64.0	53.1	64.4	61.8	52.8	150	117.0
Kawvale	8180	----	----	----	----	----	----	----	----	----	53.8	53.8	57.8	21	93.1
Harvest Queen	6199	----	----	----	----	----	----	46.3	51.8	37.2	----	44.9	51.4	57	87.4
Fulcaster	6471	----	----	----	----	----	----	37.9	41.5	28.1	44.6	38.1	53.1	78	71.8

There are nine varieties that have been grown in the experiments throughout the 10-year period. In Table 7 the average annual survivals for these varieties and their rank each year are given. The varieties are arranged in the order of their weighted average survivals. The average survivals of these nine varieties are shown graphically in Figure 2.

The relative hardiness of the above nine varieties in comparison with other varieties in the experiment is shown by their yearly ranking. In the earlier years Minhardi, Buffum No. 17, Minturki, and Odessa ranked well toward the top, while Kharkof ranked from eighth to sixteenth. New hybrid material was added to the nursery from 1925 on, and as a result the relative position of the standard varieties has lowered.

TABLE 7.—*Average survival and annual rank of nine varieties of winter wheat grown during each of 10 years at 9 to 21 stations where partial winterkilling occurred, together with the weighted average percentage of survival of each variety for the 10-year period*

Variety	C. I. No.	Survival (per cent) and rank in—											
		1920 (9 stations, 22 varieties)		1921 (12 stations, 18 varieties)		1922 (11 stations, 20 varieties)		1923 (9 stations, 24 varieties)		1924 (16 stations, 27 varieties)		1925 (15 stations, 28 varieties)	
		Survival	Rank	Survival	Rank	Survival	Rank	Survival	Rank	Survival	Rank	Survival	Rank
Minhardi	5149	37.4	1	84.3	1	67.4	1	55.6	2	70.0	2	69.7	2
Buffum No. 17	3330	33.2	2	83.5	4	57.5	3	57.2	1	67.5	3	72.5	1
Minturki	6155	31.1	5	84.2	2	60.9	2	53.8	3	67.4	4	64.3	4
Odessa	6151	32.4	3	80.8	7	55.6	5	49.3	9	70.9	1	66.7	3
Turkey (selection)	6152	30.7	8	83.2	5	53.9	6	47.7	10	65.8	6	63.0	7
Nebraska No. 60	6250	26.8	20	80.8	8	51.5	7	45.2	12	63.1	9	60.5	8
Kanred	5146	29.8	13	78.3	11	48.4	13	49.8	8	62.8	10	48.1	15
Montana No. 36	5549	30.3	10	79.7	9	49.5	10	41.7	18	60.4	17	47.1	16
Kharkof	1442	29.8	14	77.3	13	50.2	8	44.3	13	60.6	16	43.7	19

Variety	C. I. No.	Survival (per cent) and rank in—								Weighted average of survival (per cent)
		1926 (18 stations, 30 varieties)		1927 (19 stations, 30 varieties)		1928 (20 stations, 30 varieties)		1929 (21 stations, 30 varieties)		
		Survival	Rank	Survival	Rank	Survival	Rank	Survival	Rank	
Minhardi	5149	70.4	3	69.4	2	59.5	5	65.2	3	66.0
Buffum No. 17	3330	69.7	4	69.7	1	64.5	1	66.1	1	65.8
Minturki	6155	66.1	10	64.7	8	58.8	6	64.1	7	62.9
Odessa	6151	66.2	9	64.0	12	53.1	12	64.4	6	61.8
Turkey (selection)	6152	64.7	14	62.5	16	50.6	15	60.4	17	59.5
Nebraska No. 60	6250	59.7	17	61.6	18	47.5	17	58.0	20	56.8
Kanred	5146	52.4	24	58.3	23	45.8	18	60.7	16	54.4
Montana No. 36	5549	58.0	19	58.9	22	42.4	22	59.9	18	53.9
Kharkof	1442	56.7	21	55.5	26	42.8	21	57.8	21	52.8

YIELD DATA FROM HARDINESS NURSERIES

Several cooperators have reported yields from the winter-hardiness nurseries each year since 1926. Only nurseries with fairly good survivals were harvested. It is realized that competition was not controlled in the triplicated single-rod-row plantings, yet it is be-

lieved that the average results from several stations give rather comparable data. It therefore has not seemed advisable to use statistical constants in an attempt to establish significant differences.

RESULTS IN 1926

In 1926 yields were reported from 14 of the 26 nurseries. The data are presented in Table 8. The yields were fairly high at most of the stations, except that the tender varieties had very low or no yields in some cases. The varieties having the highest average yields were Minhardi × Minturki (C. I. 8034), Minturki, Minturki × Beloglina–Buffum (C. I. 8033), Beloglina (C. I. 1667), and Turkey × Minessa. Fulcaster, Harvest Queen, and Blackhull gave the lowest average yields.

RESULTS IN 1927

Yield data from 18 stations in 1927 are presented in Table 9. The stations were well scattered throughout the area in which the hardiness nurseries are grown. Yields were high except at Manhattan, Kans., where the results were extremely variable, and at Dickinson, N. Dak., where the yields were very low. The yields averaged slightly lower than in 1926. At the two Kansas stations reporting yields those hardy varieties which are late in maturity had very low yields. The varieties having the highest average yields were Kanred, Minhardi × Minturki (C. I. 8034), Beloglina (C. I. 1667), and Minturki × Beloglina-Buffum (C. I. 8033). Minhardi, Kharkof Selection (C. I. 6938), and Kanred × Minhardi (C. I. 8031) gave the lowest average yields.

RESULTS IN 1928

In 1928 yield results were obtained from 15 stations and the data are presented in Table 10. At St. Paul, Minn., and Morden, Manitoba, only the more hardy varieties produced grain. At Moccasin, Mont., yields were very low, owing to an attack of foot rot and to very dry spring growing conditions. At the other stations the yields were fairly consistent. Minturki × Beloglina-Buffum (C. I. 8033), Minhardi × Minturki (C. I. No. 8034), Minturki, and Kanred gave the highest average yields. Fulcaster, Regal, Superhard, and Blackhull gave the lowest average yields. Oro had an average yield equal to Kharkof check, while Tenmarq yielded about 1 bushel more.

RESULTS IN 1929

Yield data were received from only 10 stations in 1929. They are presented in Table 11. At Hays, Kans., yields were obtained from two replications, while at Edmonton, Alberta, the yields were from only one replication. At Brookings, S. Dak., the nursery was grown in single 3-row plots, the middle row being harvested for yield. Since most of the stations reporting yields were those where killing was not heavy, the less hardy varieties naturally gave good yields. Kanred, Kawvale, Tenmarq, and Minturki × Beloglina-Buffum (C. I. 8033) had the highest average yields. Kanred × Minhardi (C. I. 8031), Buffum No. 17, Kanred × Minhardi (C. I. 8040), and Odessa gave the lowest yields. At the southern stations the winter-hardy, late-maturing varieties gave very poor yields.

TABLE 8.—*Average yield of 30 varieties or strains of winter wheat grown in triplicated rod rows, as uniform winter-hardiness nurseries, at 14 experiment stations in the northern United States and in Canada, 1925–26*

Class and variety	C. I. No.	State No.	Yield (bushels per acre) at—														Average, 14 stations
			Manhattan, Kans.	Hays, Kans.	Ames, Iowa	North Platte, Nebr.	St. Paul, Minn.	Bozeman, Mont.	Moccasin, Mont.	Havre, Mont.	Pullman, Wash.	Ottawa, Ontario	Indian Head, Saskatchewan	Saskatoon, Saskatchewan	Lethbridge, Alberta	Edmonton, Alberta	
Hard red winter:																	
Kharkof	1442		28.2	15.9	58.5	11.1	5.1	53.0	38.4	26.6	38.4	53.9	41.9	52.2	38.9	53.1	36.8
Montana No. 36	5549	Mont. 36	28.2	17.1	58.3	11.6	6.6	59.6	32.8	18.9	38.1	55.5	50.1	40.9	35.3	50.7	36.0
Karmont	6700		27.1	15.5	57.8	11.6	6.2	52.2	29.9	25.9	37.9	55.7	27.9	39.0	37.8	50.0	33.9
Turkey (selection)	6152	Minn. 1488	30.8	15.3	64.0	7.7	14.7	58.5	42.2	23.3	38.5	56.1	55.3	38.0	30.9	48.3	37.4
Nebraska No. 60	6250	Nebr. 60	25.9	18.6	56.3	11.1	5.6	62.7	30.5	22.3	42.9	52.9	45.4	33.5	28.6	44.0	34.3
Beloglina	1543		24.8	17.2	59.2	13.4	11.9	44.8	31.7	20.5	32.0	53.2	41.8	50.3	32.1	59.4	35.2
Do	1667		26.4	13.1	66.2	8.1	13.2	53.2	35.9	19.3	41.6	51.5	47.6	51.5	28.8	80.7	38 4
Blackhull	6251		24.8	20.4	54.8	8.0	0	60.2	25.6	15.9	32.7	53.7	3.3	6.2	23.7	42.7	26.6
Newturk	6935		27.8	18.7	53.0	11.4	11.8	48.5	33.6	21.8	35.4	55.4	39.8	53.9	33.5	69.5	36.7
Iobred	6934	Iowa 1949	23.4	19.7	59.2	8.0	7.7	54.8	23.9	15.9	34.5	53.5	26.0	18.7	20.6	35.9	28.7
Ashkof	6680	Wis. 11.825	16.0	7.9	53.0	6.4	12.7	53.0	29.7	26.1	29.6	52.9	31.5	20.6	35.7	44.1	29.9
Kharkof (selection)	6938	M. C. 2212	13.9	8.6	54.8	9.5	10.8	59.3	30.1	17.4	29.3	50.5	54.7	43.9	27.3	54.1	33.2
Minard	6690	Minn. 2199	19.5	12.7	53.3	8.6	14.0	66.6	31.2	23.9	35.7	55.0	28.4	43.9	36.3	58.4	34.8
Padui	6153	Minn. 1491	16.9	7.1	55.0	5.9	13.3	70.2	31.2	24.0	30.6	51.3	38.4	28.6	25.3	34.6	30.9
Minturki	6155	Minn. 1507	20.2	8.1	57.7	9.2	20.9	72.1	34.6	18.6	35.6	55.2	85.0	59.3	30.2	53.9	40.0
Tenmarq	6936	Kans. 439	20.5	18.0	60.3	12.9	2.6	70.6	28.3	19.9	37.7	64.5	4.0	17.7	23.1	53.5	31.0
Kanmarq	6937	Kans. 440	16.3	15.5	54.7	8.2	3.1	64.8	26.5	21.1	32.7	60.6	11.1	19.4	24.2	47.8	29.0
P–1068 × Preston	8027	Kans. 446	21.8	20.2	59.5	7.8	5.6	65.8	36.9	21.1	34.0	57.3	10.8	36.4	30.3	52.8	32.9
Kanred	5146	Kans. 2401	27.9	21.3	53.5	6.3	6.6	64.9	25.2	18.3	43.8	62.0	18.1	34.2	32.0	58.4	33.8
Turkey × Minessa	8028		18.6	9.7	55.0	5.9	19.5	49.3	37.6	27.2	37.3	55.5	77.5	39.9	28.3	71.4	38.1
Kanred × Buffum No. 17	8030		17.0	15.8	51.5	7.7	18.8	59.5	27.5	23.4	39.3	53.7	55.5	34.0	31.1	56.0	35.1
Kanred × Minhardi	8031		19.1	12.6	48.2	13.0	14.3	57.9	34.9	26.2	27.8	53.2	30.3	36.9	31.4	63.3	33.5
Kanred × Minturki	8032		26.7	16.4	51.2	11.2	7.5	63.9	23.1	15.4	44.4	68.5	14.0	23.6	37.7	51.8	32.5
Minturki × Beloglina-Buffum	8033		19.2	13.5	60.3	11.4	19.4	56.6	32.2	26.1	44.5	53.1	68.2	59.8	30.5	58.2	39.5
Minhardi × Minturki	8034		26.2	19.3	65.0	10.1	17.0	76.6	38.6	19.7	43.2	62.8	46.3	29.1	32.6	72.9	40.0
Soft red winter:																	
Buffum No. 17	3330		12.7	6.2	46.7	3.6	19.9	39.1	28.1	20.4	22.7	46.0	40.2	42.3	38.7	46.1	29.5
Minhardi	5149	Minn. 1505	19.2	13.9	45.3	9.3	16.3	50.9	33.2	23.9	31.2	52.9	36.6	34.5	30.5	51.5	32.1
Odessa	6151	Minn. 1471	6.2	3.6	51.0	5.3	20.7	35.7	34.6	17.1	29.6	56.4	68.8	29.8	34.3	60.1	32.4
Harvest Queen	6199	Kans. 19	16.7	19.2	49.7	12.4	3.5	46.4	33.6	17.1	33.2	61.5	3.4	17.7	28.1	41.1	27.4
Fulcaster	6471	Kans. 317	21.6	25.0	54.8	9.7	0	44.0	16.6	6.7	------	53.2	7.1	5.0	27.0	22.1	[1] 22.5

[1] Average of 13 stations.

TABLE 9.—*Average yield of 30 varieties or strains of winter wheat grown in triplicated rod rows, as uniform winter-hardiness nurseries, at 18 experiment stations in the northern United States and in Canada, 1926–27*

Class and variety	C. I. No.	State No.	Yield (bushels per acre) at—																		Average, 18 stations
			Manhattan, Kans.	Hays, Kans.	Ames, Iowa	Lincoln, Nebr.	North Platte, Nebr.	St. Paul, Minn.	Brookings, S. Dak.	Dickinson, N. Dak.	Bozeman, Mont.	Moccasin, Mont.	Havre, Mont.	Pullman, Wash.	Ithaca, N. Y.	Ste. Anne de Bellevue, Quebec	Ottawa, Ontario	Indian Head, Saskatchewan	Lethbridge, Alberta	Edmonton, Alberta	
Hard red winter:																					
Kharkof	1442		19.1	22.4	29.4	42.6	23.0	36.8	19.4	0	48.0	36.5	45.5	30.1	26.4	43.8	24.5	36.6	30.7	42.3	31.0
Montana No. 36	5549	Mont. 36	25.5	24.3	32.0	34.3	33.2	30.1	17.7	0	63.3	37.2	38.9	29.1	31.2	40.3	33.9	39.0	29.0	51.8	32.8
Karmont	6700		11.9	21.9	28.4	29.6	31.7	25.9	18.3	0	58.0	35.6	39.8	31.5	27.0	39.7	28.5	30.6	23.4	58.2	30.0
Turkey (selection)	6152	Minn. 1488	9.8	10.0	29.5	27.9	23.1	33.2	13.9	1.5	59.3	32.2	37.2	27.9	29.1	51.5	56.8	30.8	33.1	45.8	30.7
Nebraska No. 60	6250	Nebr. 60	25.7	17.2	33.7	35.4	32.6	31.5	15.6	0	68.3	33.9	35.4	28.1	23.8	40.9	41.1	34.0	25.5	50.1	31.8
Beloglina	1543		7.6	22.5	28.8	25.5	31.2	38.9	18.7	2.0	65.3	37.3	37.4	23.0	25.5	38.1	35.4	38.5	40.4	57.5	31.9
Do	1667		7.5	16.4	33.0	35.4	37.7	40.0	21.4	1.5	51.3	37.9	38.5	33.3	27.9	42.2	34.0	38.9	45.0	71.9	34.1
Blackhull	6251		40.7	25.5	31.8	46.2	22.2	15.8	11.0	0	77.3	19.1	28.3	19.1	39.8	43.7	33.9	39.0	0	31.4	29.2
Kanred	5146	Kans. 2401	19.1	20.4	34.0	41.8	34.2	37.8	21.8	0	45.0	40.7	48.2	19.3	25.0	39.4	42.3	33.9	37.5	75.2	34.2
Tenmarq	6936	Kans. 439	32.9	17.3	37.6	42.8	25.7	23.6	8.6	0	60.0	22.5	33.5	19.6	37.2	46.5	49.2	43.8	18.1	36.7	30.9
Newturk	6935		7.7	18.8	29.0	34.9	27.8	22.0	13.5	.8	52.0	36.2	43.6	31.3	27.6	36.2	33.9	42.8	34.8	56.9	30.5
Iobred	6934	Iowa 1949	27.2	19.0	34.4	22.9	19.8	25.9	18.9	2.5	54.0	31.9	30.8	23.6	26.4	42.3	45.1	39.7	20.2	35.7	28.9
Ashkof	6680	Wis. 11.825	10.1	9.8	30.1	30.6	22.4	31.9	11.9	.7	70.7	40.6	34.6	23.5	25.9	46.8	45.5	41.9	23.6	77.9	32.1
Kharkof (selection)	6938	M. C. 2212	4.3	6.3	19.3	27.6	19.5	23.6	18.9	3.3	36.7	35.3	35.2	20.9	12.3	20.5	34.3	33.8	46.8	42.7	24.5
Minard	6690	Minn. 2199	9.2	13.3	27.7	36.0	19.1	28.8	15.8	5.8	73.7	35.7	35.4	22.2	32.4	47.2	48.5	38.3	42.0	54.2	32.5
Padui	6153	Minn. 1491	15.5	4.5	24.3	25.7	17.8	22.7	14.0	.8	58.3	37.7	33.9	27.1	12.0	42.3	40.2	50.6	26.0	74.6	29.3
Minturki	6155	Minn. 1507	23.4	14.8	41.9	34.1	24.3	31.5	24.4	1.5	61.3	29.3	36.1	21.9	20.5	38.4	45.7	39.2	24.2	50.0	31.3
Turkey × Minessa	8028		14.0	9.3	27.6	24.0	21.4	31.6	17.5	.7	59.7	35.8	41.8	19 3	23.1	35.3	41.3	38.8	37.6	72.4	30.6
Kanred × Buffum No. 17	8030		10.3	10.3	28.5	36.0	21.2	24.5	12.4	2.5	53.0	39.9	36 8	27.6	16.3	39.4	52.3	35.0	39.2	62.4	30.4
Kanred × Minhardi	8031		8.3	11.1	23.8	20.8	19.1	22.7	18.8	0	40.0	33.7	36.6	25.1	12.6	31.3	31 2	24.6	44.3	56.2	25.6
Minturki × Beloglina-Buffum	8033		7.6	12.7	32.4	33.0	24.6	29.3	22.6	6.0	68.7	39.9	41.2	25.4	17.8	36.2	50.3	41.8	40.9	74.9	33.6
Minhardi × Minturki	8034		34.1	17.0	24.9	40.7	21.7	27.8	18.4	1.3	61.5	36.2	48.3	28.9	23.4	48.1	46.6	37.6	26.0	73.9	34.2
Eureka × Minhardi	8036		18.0	14.7	------	31.2	26.9	27.4	18.7	4.3	51.3	41.8	39.2	23.8	17.8	34.7	46.4	29.4	41.2	55 6	[1] 30.7
Kanred × Minhardi	8040		1.9	8.7	29.5	19.0	23.3	28.4	13.2	3.2	62.0	38.9	45.8	22.9	13.2	43.3	36.4	24.7	40.5	61.2	28.7
Minhardi × Minturki	8047		14.6	21.0	27.0	36.7	17.5	29.2	15.5	1.5	63.3	33.2	43.8	25.4	23.2	42.2	51.3	40.8	28.3	64.3	32.2
Soft red winter:																					
Buffum No. 17	3330		5.1	7.0	28.3	18.8	16.1	23.3	11.5	2.7	50.0	33.6	38.3	24.2	8.9	35.4	34.0	27.7	36.8	62.0	25.8
Minhardi	5149	Minn. 1505	8.6	10.2	16.7	20.0	20.7	30.3	14.7	1.7	25.3	36.1	40.9	19.4	12.6	35.3	41.9	18.7	44.0	42.8	24.4
Odessa	6151	Minn. 1471	2.5	4.2	23.8	10.5	11.0	26.3	9.1	2.0	56.7	37.8	43.3	23.3	12.2	43.3	53.7	33.7	25.7	62.0	26.7
Harvest Queen	6199	Kans. 19	24.4	13.5	17.2	24.9	21.2	30.2	14.5	0	49.3	32.5	38.9	12.9	22.2	45.5	44.1	26 6	22.2	44.6	26.9
Fulcaster	6471	Kans. 317	56.1	14.5	33.4	27.2	21.0	18.4	10.3	0	63.3	18.3	28.9	17.0	24.7	45.0	44.2	32.3	0	30.5	27.0

[1] Average of 17 stations.

TABLE 10.—*Average yield of 30 varieties or strains of winter wheat grown in triplicated rod rows, as uniform winter-hardiness nurseries, at 15 experiment stations in the northern United States and in Canada, 1927–28*

Class and variety	C.I. No.	State No.	Yield (bushels per acre) at—															Average, 15 stations
			Manhattan, Kans.	Hays, Kans.	Ames, Iowa	Lincoln, Nebr.	North Platte, Nebr.	St. Paul, Minn.	Dickinson, N. Dak.	Bozeman, Mont.	Moccasin, Mont.	Havre, Mont.	Pullman, Wash.	Ithaca, N. Y.	Ottawa, Ontario	Morden, Manitoba	Edmonton, Alberta	
Hard red winter:																		
Kharkof	1442		47.3	49.0	29.7	21.3	35.2	0	12.2	72.3	0.3	21.9	50.0	17.9	42.6	0	[1]47.9	29.8
Kharkof (selection)	6938	M. C. 2212	35.2	12.4	59.8	23.1	41.1	0	8.9	49.0	19.3	34.0	35.0	20.9	40.7	0	51.5	28.7
Montana No. 36	5549	Mont. 36	44.2	41.5	24.0	20.2	43.8	0	4.7	58.0	.8	24.8	54.0	14.8	41.1	0	39.3	27.4
Karmont	6700		43.0	40.2	19.2	22.0	43.1	0	10.5	44.1	.6	27.1	50.0	12.7	41.5	0	46.4	26.7
Newturk	6935		43.6	30.1	26.5	22.7	35.5	0	5.4	65.0	.9	34.1	54.0	10.5	45.3	0	42.8	27.8
Regal	7364		31.8	29.3	3.0	13.2	12.7	0	4.0	56.9	0	15.0	51.0	17.7	47.3	0	37.0	21.3
Oro	8220		50.3	41.4	43.2	20.2	48.8	0	6.2	63.0	1.4	30.2	49.0	23.0	33.6	0	[1]36.3	29.8
Beloglina	1543		42.6	29.9	39.0	20.4	57.1	0	15.3	42.1	2.3	36.1	41.0	13.2	40.7	0	46.1	28.4
Nebraska No. 60	6250	Nebr. 60	44.6	33.4	33.5	19.1	45.4	0	11.5	61.7	3.2	25.9	53.0	15.9	39.8	0	37.7	28.3
Kanred	5146	Kans. 2401	56.3	41.2	36.5	19.0	58.2	0	5.0	58.1	.3	36.9	47.0	12.5	50.2	0	52.0	31.5
Blackhull	6251		47.0	25.6	12.8	19.8	38.6	0	2.2	48.2	0	11.9	41.0	15.2	45.0	0	21.8	21.9
Superhard	8054		44.9	31.7	1.2	20.8	18.3	0	2.0	46.1	0	20.0	43.0	11.9	56.4	0	29.9	21.7
Tenmarq	6936	Kans. 439	56.3	31.7	30.7	19.7	44.7	0	5.3	79.4	0	22.9	46.0	20.2	71.9	0	35.3	30.9
Iobred	6934	Iowa 1949	38.1	21.0	26.5	17.7	33.0	0	8.2	40.7	0	16.3	42.0	17.4	43.0	0	27.4	22.1
Turkey × Minessa	8028		35.8	16.6	40.5	15.8	44.3	.7	13.9	36.8	13.7	31.5	36.0	22.9	46.1	14.3	43.3	27.5
Kanred × Buffum No. 17	8030		43.6	36.5	26.7	20.0	44.5	2.3	25.1	54.9	5.7	36.5	46.0	17.9	32.4	14.6	50.9	30.5
Kanred × Minhardi	8031		30.4	21.5	28.0	17.8	50.6	6.3	4.0	45.6	7.7	24.9	49.0	13.1	34.6	0	35.3	24.6
Minturki × Beloglina-Buffum	8033		52.6	38.8	38.2	23.4	42.8	8.2	18.7	55.6	7.6	35.6	43.0	13.6	60.1	22.0	44.8	33.7
Minhardi × Minturki	8034		49.0	46.8	37.7	19.9	51.9	2.9	12.7	66.0	4.4	29.8	47.0	21.0	58.2	11.5	40.4	33.3
Eureka × Minhardi	8036		39.1	31.7	34.8	18.7	54.3	24.3	7.5	52.4	14.1	30.6	48.0	15.2	48.5	6.9	41.2	31.2
Turkey (selection)	6152	Minn. 1488	48.9	32.6	29.2	16.8	40.9	13.1	6.2	44.6	3.1	20.2	44.0	21.5	49.0	14.4	[1]31.6	27.7
Minturki	6155	Minn. 1507	49.2	41.2	39.3	20.9	51.3	12.3	13.0	57.5	8.8	29.0	43.0	18.8	58.9	18.4	36.8	33.2
Minard	6690	Minn. 2199	29.8	42.2	28.8	13.5	47.5	8.0	11.1	57.4	2.9	26.4	49.0	21.1	33.8	21.3	39.9	28.8
Minhardi × Minturki	8215	Minn. II–19–7	34.9	15.1	32.0	17.0	49.9	33.7	8.8	44.4	9.0	26.9	40.0	16.9	52.4	19.9	30.1	28.7
Turkey × Minhardi	8217	Minn. II–19–31	42.5	36.0	33.0	15.2	44.8	15.6	12.6	50.9	7.6	------	44.0	28.9	51.5	11.7	34.6	[2]30.6
Soft red winter:																		
Minhardi	5149	Minn. 1505	37.1	20.2	33.7	16.2	44.5	16.4	9.3	25.9	14.8	------	39.0	14.7	51.8	0	36.2	[2]25.7
Odessa	6151	Minn. 1471	33.9	22.3	18.0	[1]16.6	25.9	3.7	8.7	53.1	3.8	------	37.0	16.4	55.3	0	48.8	[2]24.5
Buffum No. 17	3330		34.5	24.5	38.2	[1]25.7	40.1	12.0	21.7	46.2	10.5	50.3	34.0	11.2	36.9	26.5	41.7	30.3
Harvest Queen	6199		49.7	32.3	26.5	17.7	45.0	0	5.3	53.7	0	17.3	42.0	19.9	63.8	0	32.5	27.0
Fulcaster	6471		44.8	22.1	3.0	11.9	18.1	0	1.9	40.7	0	12.5	36.0	20.1	20.3	0	[1]24.6	17.1

[1] One replication only.

[2] Average of 14 stations.

TABLE 11.—*Average yield of 30 varieties or strains of winter wheat grown in triplicated rod rows, as uniform winter-hardiness nurseries, at 10 experiment stations in the United States and in Canada, 1928–29*

Class and variety	C. I. No.	State No.	Yield (bushels per acre) at—										
			Manhattan, Kans.	Hays, Kans.[1]	Ames, Iowa	Lincoln, Nebr.	Brookings, S. Dak.[2]	Redfield, S. Dak.	St. Paul, Minn.	Bozeman, Mont.	Moccasin, Mont.	Edmonton, Alberta[3]	Average, 10 stations
Hard red winter:													
Kharkof	1442		21.3	23.5	22.7	45.4	22.0	15.0	31.8	49.7	15.0	3.1	25.0
Kharkof (selection)	6938	M. C. 2212	18.1	11.0	28.7	40.0	22.3	18.3	47.0	43.7	18.3	3.2	25.1
Montana No. 36	5549	Mont. 36	19.4	23.2	26.3	39.6	20.8	12.7	30.1	48.7	16.5	3.0	24.0
Karmont	6700		19.8	20.2	19.5	35.5	24.2	16.0	26.2	52.1	16.1	3.2	23.3
Newturk	6935		13.5	19.1	22.8	37.1	18.2	16.8	33.1	49.8	20.2	8.0	23.9
Oro	8220		21.3	20.8	21.3	34.6	25.1	11.7	42.1	52.0	15.0	5.0	24.9
Beloglina	1543		24.4	19.1	22.5	25.8	29.4	19.5	37.9	50.9	17.8	6.8	25.4
Nebraska No. 60	6250	Nebr. 60	21.2	21.2	29.8	42.5	24.5	15.5	29.6	55.4	23.2	6.2	26.9
Kanred	5146	Kans. 2401	28.4	22.1	34.7	56.2	30.9	18.4	46.5	55.9	19.9	9.3	32.2
Blackhull	6251		19.2	31.4	26.3	39.6	27.6	4.9	23.1	57.0	17.1	4.1	25.0
Superhard	8054		18.3	32.6	29.5	50.4	24.1	7.2	29.3	51.8	20.4	5.8	26.9
Early Blackhull	8856		25.2	31.1	26.7	35.4	15.2	2.0	23.7	39.1	19.1	2.5	22.0
Tenmarq	6936	Kans. 439	30.8	31.0	34.2	58.2	23.7	9.1	36.1	61.4	21.9	7.2	31.4
Kanred × Buffum No. 17	8030		22.3	12.4	27.2	35.8	26.2	20.1	54.5	53.0	16.6	12.3	28.0
Kanred × Minhardi	8031		11.8	9.1	17.0	23.9	17.8	11.1	30.5	36.6	15.2	15.8	18.9
Minturki × Beloglina-Buffum	8033		21.9	14.9	29.7	38.2	23.2	15.9	50.5	61.5	22.9	15.0	29.4
Minhardi × Minturki	8034		26.9	17.3	31.7	41.9	24.2	13.2	44.9	46.9	26.0	14.2	28.7
Eureka × Minhardi	8036		18.7	15.9	28.7	29.2	18.5	14.6	39.4	48.0	17.7	10.5	24.1
Kanred × Minhardi	8040		10.8	11.2	19.0	26.3	22.7	12.7	32.3	41.7	27.1	11.8	21.6
Turkey (selection)	6152	Minn. 1488	20.9	18.9	24.7	34.3	21.1	10.6	33.6	48.9	17.4	8.5	23.9
Minturki	6155	Minn. 1507	30.3	19.1	28.3	45.1	32.5	13.8	40.0	44.2	20.4	12.0	28.6
Minhardi × Minturki	8215	Minn. II–19–7	23.7	16.6	24.8	34.4	26.2	13.1	34.1	45.4	19.9	9.2	24.7
Turkey × Minhardi	8216	Minn. II–19–29	19.3	27.9	20.7	31.8	21.3	13.4	29.4	42.6	17.4	11.1	23.5
Do	8217	Minn. II–19–31	22.0	14.6	28.0	38.4	14.2	13.4	35.9	63.3	22.0	12.3	26.4
Minard × Minhardi	8218	Minn. II–20–20	21.3	16.3	26.7	31.6	13.1	13.1	34.3	43.5	15.7	8.5	22.4
Soft red winter:													
Minhardi	5149	Minn. 1505	16.3	13.2	24.3	24.0	19.4	12.6	37.0	45.7	19.5	14.0	22.6
Odessa	6151	Minn. 1471	11.6	8.2	23.3	25.2	16.4	10.1	37.3	47.2	16.8	19.8	21.6
Buffum No. 17	3330		11.1	5.3	18.5	17.3	15.3	11.0	36.9	48.7	14.3	21.4	20.0
Kawvale	8180	Kans. 2593	41.5	33.8	34.3	53.8	28.2	8.7	37.1	42.2	23.7	14.5	31.8
Fulcaster	6471	Kans. 317	27.5	30.9	28.3	27.0	18.8	4.7	25.7	43.9	16.5	15.0	23.8

[1] Two replications.
[2] Grown in a single 3-row plot, middle row harvested for yield.
[3] Single rows.

SUMMARY OF YIELD DATA

The annual and average yields in bushels per acre of the 42 varieties harvested during one or more of the four years from 1926 to 1929 are presented in Table 12. For the varieties grown throughout the 4-year period yield data are available for 57 station years. The weighted average is shown for each variety, together with the average of Kharkof check for the same years. The varieties are ranked according to yield within their classes, yields being stated as percentage of Kharkof. Ten varieties had higher average yields than Kharkof. Data for two of these varieties, Kawvale and Minhardi × Minturki (C. I. 8047), cover only one year. Kawvale, harvested only in 1929, had the highest yield of any variety, owing in part to the fact that several of the stations reporting yields of Kawvale had very little winterkilling.

Among the hard red winter varieties two hybrid strains, Minhardi × Minturki (C. I. 8034) and Minturki × Beloglina-Buffum (C. I. 8033), ranked the highest. Following these strains were Minturki,

Beloglina (C. I. 1667), and Kanred. Tenmarq had a lower average yield than Kanred. Oro, harvested in two years, had an average yield about equal to that of the Kharkof check. The lower yielding varieties were chiefly those lacking hardiness, such as Blackhull, Superhard, and Regal, and very late, hardy varieties, such as Kanred × Minturki (C. I. 8032) and Kanred × Minhardi (C. I. 8031).

Among the varieties classed as soft red winter none had a high average yield except Kawvale. The three soft varieties for which data are available for each of the four years, Buffum No. 17, Odessa, and Minhardi, had yields very nearly equal. Although harvested during three years only, Harvest Queen slightly outyielded Fulcaster.

TABLE 12.—*Annual and average yields of 42 varieties of wheat harvested during one or more of the four years from 1926 to 1929*

Class and variety	C. I. No.	Yield (bushels per acre)						Number of station years	Percentage of Kharkof
		1925–26 (14 stations)	1926–27 (18 stations)	1927–28 (15 stations)	1928–29 (10 stations)	Average (weighted)	Kharkof same years		
Hard red winter:									
Minhardi × Minturki	8034	40.0	34.2	33.3	28.7	34.4	31.1	57	110.6
Minturki × Beloglina-Buffum	8033	39.5	33.6	33.7	29.4	34.3	31.1	57	110.6
Minturki	6155	40.0	31.3	33.2	28.6	33.5	31.1	57	107.7
Beloglina	1667	38.4	34.1	------	------	36.0	33.5	32	107.5
Kanred	5146	33.8	34.2	31.5	32.2	33.0	31.1	57	106.1
Turkey × Minhardi	8217	------	------	[1] 30.6	26.4	28.9	28.2	24	102.5
Minhardi × Minturki	8047	------	32.2	------	------	32.2	31.0	18	103.9
Eureka × Minhardi	8036	------	[2] 30.7	31.2	24.1	29.3	29.1	42	100.7
Kanred × Buffum No. 17	8030	35.1	30.4	30.5	28.0	31.2	31.1	57	100.3
Kharkof	1442	36.8	31.0	29.8	25.0	31.1	------	57	100.0
Tenmarq	6936	31.0	30.9	30.9	31.4	31.0	31.1	57	99.7
Oro	8220	------	------	29.8	24.9	27.8	27.9	25	99.6
Minard	6690	34.8	32.5	28.8	------	32.0	32.3	47	99.1
Turkey × Minessa	8028	38.1	30.6	27.5	------	31.8	32.3	47	98.5
Beloglina	1543	35.2	31.9	28.4	25.4	30.6	31.1	57	98.4
Montana No. 36	5549	36.0	32.8	27.4	24.0	30.6	31.1	57	98.4
Nebraska No. 60	6250	34.3	31.8	28.3	26.9	30.6	31.1	57	98.4
Turkey (selection)	6152	37.4	30.7	27.7	23.9	30.4	31.1	57	97.7
Minhardi × Minturki	8215	------	------	28.7	24.7	27.1	27.9	25	97.1
Newturk	6935	36.7	30.5	27.8	23.9	30.2	31.1	57	97.1
Turkey × Minhardi	8216	------	------	------	23.5	23.5	25.0	10	94.0
Karmont	6700	33.9	30.0	26.7	23.3	28.9	31.1	57	92.9
Ashkof	6680	29.9	32.1	------	------	31.1	33.5	32	92.8
Kanred × Minhardi	8040	------	28.7	------	21.6	26.2	28.9	28	90.7
Padui	6153	30.9	29.3	------	------	30.0	33.5	32	89.6
Minard × Minhardi	8218	------	------	------	22.4	22.4	25.0	10	89.6
P–1068 × Preston	8027	32.9	------	------	------	32.9	36.8	14	89.4
Kharkof (selection)	6938	33.2	24.5	28.7	25.1	27.8	31.1	57	89.4
Kanred × Minturki	8032	32.5	------	------	------	32.5	36.8	14	88.3
Early Blackhull	8856	------	------	------	22.0	22.0	25.0	10	88.0
Superhard	8054	------	------	21.7	26.9	23.8	27.9	25	85.3
Kanred × Minhardi	8031	33.5	25.6	24.6	18.9	26.1	31.1	57	83.9
Blackhull	6251	26.6	29.2	21.9	25.0	25.9	31.1	57	83.3
Iobred	6934	28.7	28.9	22.1	------	26.7	32.3	47	82.7
Kanmarq	6937	29.0	------	------	------	29.0	36.8	14	78.8
Regal	7364	------	------	21.3	------	21.3	29.8	15	71.5
Soft red winter:									
Kawvale	8180	------	------	------	31.8	31.8	25.0	10	127.2
Buffum No. 17	3330	29.5	25.8	30.3	20.0	26.9	31.1	57	86.5
Odessa	6151	32.4	26.7	[1] 24.5	21.6	26.7	31.2	56	85.6
Minhardi	5149	32.1	24.4	[1] 25.7	22.6	26.3	31.2	56	84.3
Harvest Queen	6199	27.4	26.9	27.0	------	27.1	32.3	47	83.9
Fulcaster	6471	[3] 22.5	27.0	17.1	23.8	22.7	30.9	56	73.5

[1] Average of 14 stations. [2] Average of 17 stations. [3] Average of 13 stations.

DISCUSSION

To be of practical value a variety of hard winter wheat should be able to withstand the winter weather and to produce a high yield of grain of good quality. Not only is it desirable to have a variety that

can withstand severe winter weather, but also it must be able to recover quickly when growth starts in the spring, and make the best use of the available moisture and plant food. Notes on survival taken in the spring give a measure of the hardiness of a given strain. It is possible for plants to be alive in the spring yet to be in a weakened condition and susceptible to the invasion of diseases, such as foot rots, which may later kill the plants. The season may be dry, and the variety should be able to make effective use of the available moisture. The stands may have been thinned out to a considerable extent, and some varieties have the ability to tiller more profusely than others, thus partly making up for the reduced stand. Finally, for sections of the country where hot winds are common, the variety should be able to mature in good season and thus escape hot winds. Yield data are necessary in order to reach a final decision regarding the value of a variety, i. e., it is of no use to grow a very hardy variety of wheat unless this variety has the ability to produce a better yield than a slightly hardy variety.

When the winter-hardiness nursery was started there were available such soft varieties as Minhardi, Buffum No. 17, and Odessa, very winter hardy but poor in quality and yield. There were also available hard varieties of good quality and with the ability to yield well when they came through the winter with fair stands. The combination of these desired characters by breeding has furnished new productions which are now a very important part of the hardiness nurseries. Some of the new hybrid selections combine a high degree of winter hardiness with the ability to yield well. Only one commercial variety, Minturki, is of this type. Some of the hybrid strains appear to be more hardy than Minturki and also yield better. Most of the hardy strains, however, are too late maturing for successful growing in the southern part of the hard red winter-wheat area.

IMPORTANT VARIETIES

MINHARDI

Minhardi shows the highest average winter survival of all varieties. It is an awnleted wheat, having glabrous white glumes, soft red kernels, and strong erect stems. It has proved to be a high-yielding variety in most field experiments, but under conditions of severe winterkilling it may outyield other varieties. It has great potential value as a parent in breeding for winter hardiness.

The Minhardi variety is a selection from a cross made at University Farm, St. Paul, Minn., in 1902, between Odessa (Minn. No. 558) and Turkey (Minn. No. 829). The wheat now known as Minhardi was increased and distributed for testing on farms about 1919, after it had shown promise in experiments, but it is not grown commercially now, as it is not equal to Minturki in yield or in quality.

MINTURKI

The Minturki variety has the third highest percentage of survival. It is a bearded wheat having glabrous white glumes and semihard red kernels. It has many of the characteristics of the Turkey variety, but is slightly taller and has longer kernels and is resistant to stem rust. In some seasons it has kernels of rather soft texture,

but usually it is of excellent bread-making value, as determined by experimental baking tests. Minturki has given high yields in experiments in Minnesota and is now the leading winter-wheat variety grown in that State.

Minturki is a selection made at the Minnesota Agricultural Experiment Station from the same hybrid from which Minhardi was selected, and it was increased and distributed at the same time.

BUFFUM No. 17

The Buffum No. 17 variety ranked second in winter survival. In general, it has shown its greatest hardiness in the semiarid sections. This variety has awnleted spikes, glabrous white glumes, and soft red kernels. It is a late-maturing variety, and probably largely for this reason it has produced relatively low yields. It has yielded best in Wyoming, but even there has not equaled Kanred and Kharkof. It is a soft red winter wheat, of good milling and baking quality for that class, but is not equal to the hard red winter varieties. It is grown on farms only to a slight extent, if at all, at the present time.

Buffum No. 17 originated from a single plant found in a field of Turkey wheat by B. C. Buffum, Worland, Wyo., who distributed it in 1912 as a hardy winter variety.

ODESSA

Odessa was the fourth hardiest variety in these experiments. It is a late-maturing variety having awnleted spikes with glabrous brown glumes and soft red kernels. Partly because of its late maturity, Odessa has produced low yields in most experiments. It is of good milling and baking quality for a soft red winter wheat. Although in itself of little value in extending the winter-wheat area or in reducing the amount of commercial winterkilling, the value of Odessa in breeding hardy winter wheats is shown by the record of Minhardi and Minturki, which are selections from a hybrid between Odessa and Turkey.

The Odessa variety was introduced into the United States many years ago, apparently from Russia. The strain tested in these experiments is a selection made at University Farm, St. Paul, Minn., from a lot of Odessa wheat (Minn. No. 943) obtained in Minnesota under the name of Berg. This selection (C. I. No. 6151) is believed to be slightly hardier than the ordinary Odessa variety.

KANRED

The Kanred variety differs from Turkey and Kharkof principally in having longer beaks and in being resistant to several forms of stem and leaf rusts. It has outyielded Turkey and Kharkof in the southern half of the Great Plains area and is about equal to those varieties in milling and baking quality. These and other experiments show Kanred to be slightly hardier than Kharkof. This increased hardiness sometimes is a factor responsible for the higher yields of Kanred in comparison with Kharkof and Turkey.

Kanred wheat is a selection from the Crimean variety made at the Kansas Agricultural Experiment Station in 1906. It was distributed

about 1917 and is now widely grown in Kansas, Nebraska, and adjoining States.

NEBRASKA No. 60

Nebraska No. 60 ranked sixth in hardiness. It can not be distinguished in appearance from Turkey and Kharkof. It has outyielded these varieties and has yielded about as well as Kanred in Nebraska except in rust years. It also equals these varieties in milling and baking qualities. It shows a slightly greater average survival in the experiments than Kanred, which indicates that it is somewhat hardier than Turkey and Kharkof.

Nebraska No. 60 is a selection from Turkey made at the Nebraska Agricultural Experiment Station and distributed in 1918. It is now grown on farms in Nebraska to a considerable extent.

KHARKOF (C. I. No. 1442)

Kharkof wheat has slender stems, awned spikes, glabrous white glumes, and hard red kernels. It was used as a standard variety in these experiments, because it is representative of most of the hard red winter wheat grown in the United States. All wheats that show a lower percentage of survival than Kharkof are unsafe for growing in the Northern States and may be severely injured during cold winters in the central Great Plains sections.

KARMONT

Karmont is a variety similar in appearance to Kharkof and Turkey. This variety is the result of a head selection from Kharkof. Karmont has given good yields under Montana conditions and is now of commercial importance in that State. Compared to Kharkof check, the Karmont variety has no more hardiness and does not have the ability to yield as well over wide areas. Its adaptation seems to be limited to Montana.

BLACKHULL

Blackhull usually may be distinguished by the black stripes on the outer glumes or by their solid black color. Under some conditions this color does not appear. The variety also differs from Turkey in being a little earlier and taller and in having stiffer straw and somewhat larger and softer kernels. Blackhull is decidedly lacking in hardiness, being among the tender varieties tested. It should be grown only where there is little danger from winterkilling.

Blackhull originated from three heads selected in 1912 from a field of Turkey wheat by Earl G. Clark, of Harvey County, Kans. It is now extensively grown in Kansas and Oklahoma, being one of the most important varieties in that area.

TENMARQ

Tenmarq is the result of a cross between Marquis and P–1066. The latter is a selection similar to Kanred. The cross was made in 1917 at Manhattan, Kans., and Tenmarq is the result of a selection made in 1921. Tenmarq is bearded, has white glabrous glumes, long beaks, and short hard red kernels. It lacks hardiness, being much less

hardy than Kharkof. It is among the varieties in the tender group, but apparently is not so tender as Blackhull. Tenmarq had an average yield in these experiments about equal to that of the Kharkof check. It made its best yields at the more southern stations where killing was not severe. Tenmarq is now being thoroughly tested at experiment stations and in cooperative tests with farmers in Kansas.

OTHER VARIETIES

Several new varieties that have been included in the tests during a part of the period from 1926 to 1929 are worthy of mention. Several hybrid strains have been tested, and from the results obtained these varieties seem to combine winter hardiness and yielding ability.

Minturki × Beloglina-Buffum (C. I. No. 8033) is very hardy, has yielded well in these tests, and is resistant to bunt. It has rather weak straw, however, and also is late maturing when grown in Kansas.

Minhardi × Minturki (C. I. No. 8034) is midhardy and seems to have high capacity for yield. This strain has a stiff straw and high-baking quality and gives promise of becoming a valuable wheat for Montana conditions.

Minhardi × Minturki (C. I. No. 8215), in the uniform nursery for two years, has been very hardy and has produced a good average yield.

Oro, a smut-resistant selection from Turkey, made at the Moro, Oreg., station, has been grown for two years and seems to be about equal to the Kharkof check in hardiness and yield. It has strong straw and is of good quality for milling and bread making.

Superhard, a selection from Blackhull, seems to be no better than that variety in hardiness or yield or in milling and baking qualities.

SUMMARY

Low temperatures cause nearly as heavy losses to the wheat crop as all wheat diseases combined.

Winter wheat is more productive than spring wheat where it survives the winter. The reduction of losses due to winterkilling would result in both increased yields and more economical production. Winter injury may be reduced by the use of hardy varieties and by sowing in stubble or cornstalks, improved methods of preparing summer-fallow, sowing with furrow drills at proper rates and dates, and by mulching the wheat with straw.

The hardiness of varieties has been determined from uniform nurseries grown at 30 experiment stations in the United States and Canada during 2 or more of the 10 years from 1920 to 1929. Detailed data are presented in this circular for the 4-year period 1926 to 1929, together with averages for the previous years. Forty-five varieties and strains have been tested since 1926, while nine of these varieties have been grown throughout the 10-year period. Data on comparative hardiness were obtained during 150 station years. These data show that the varieties Minhardi, Buffum No. 17, Minturki, Odessa, and certain new hybrid strains are consistently more hardy than the standard Kharkof used as a check in these experiments. Nebraska No. 60 and Kanred are only slightly

hardier, and Tenmarq, Blackhull, Superhard, and Fulcaster are tender or much less hardy than Kharkof.

Yield data have been obtained on surviving rows during the 4-year period 1926 to 1929 for a total of 57 station years. Two strains of Minhardi × Minturki (C. I. Nos. 8215 and 8034), Minturki × Beloglina-Buffum (C. I. No. 8033), Minturki, Beloglina (C. I. No. 1667), and Kanred have average yields considerably above the yield of Kharof. Tenmarq, Oro, and Nebraska No. 60 had average yields about equal to or slightly below the yield of Kharkof. Blackhull, Buffum No. 17, Odessa, and Minhardi gave yields much lower than did Kharkof.

Hybrid strains that combine hardiness and yielding ability are Minhardi × Minturki (C. I. Nos. 8034 and 8215) and Minturki × Beloglina-Buffum (C. I. No. 8033). These new strains give promise of becoming valuable varieties.

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